

NAUTICAL CHARTS: LEADING THE WAY

The Coast Survey and Its Successors Revolutionize Nautical Chartmaking

BY CRAIG COLLINS

When Congress and the Jefferson administration authorized the Survey of the Coast of the United States in 1807, their ambitions for the new organization could be boiled down to one thing: the nautical chart. The seas surrounding the nation's shores were still a perilous and dimly understood frontier, littered with submerged shoals and outcrops that had sunk an alarming number of ships, and Jefferson — a surveyor himself — wanted these hazards and other

features of interest mapped in order to aid mariners.

The political struggles that plagued the Survey throughout much of its early era stemmed from a disagreement between its first superintendent, Ferdinand Hassler, and rivals in the Navy about the field work these charts would require. Navy surveyors insisted that depth soundings, coupled with astronomic readings using a sextant and a chronometer, were an accurate and efficient means of conducting “hydrographic surveys” — measurements and descriptions of the physical features and conditions of navigable waters

and their shorelines. Hassler insisted that the first step was to establish a land-based survey network that would anchor these hydrographic observations to fixed reference points. For many years he was on the losing end of the dispute, and was literally dismissed from the survey for 15 years before being reinstated as Superintendent in 1832. His first hydrographic surveys were not undertaken until 1834, after Hassler had determined that the Survey's land-based surveying was developed sufficiently to support a sounding party in and around New York Harbor.

It didn't take long for Hassler to be vindicated himself. In 1835, Lt. Thomas Gedney, commander of the Survey's first hydrographic survey ship, the *Jersey*, took soundings along the entrance to New York Harbor between Long Island and Sandy Hook, N.J. Gedney discovered a deep-water channel near Long Island that led directly into the harbor and could be used by vessels anytime, regardless of water level. The deepest channel previously known had been far to the south, off the coast of Sandy Hook — where larger ships had been forced to wait for high tide and favorable winds to make the passage. Hassler wasted no time in pointing out that his methods had uncovered this channel, which had enormous implications for both the economy and the naval defense of the harbor.

Hydrographic surveys, until well into the 20th century, continued to be conducted much in the same way as Gedney had conducted his: by throwing a line over the side of a sounding boat (in later years, a reel of kink- and snag-resistant piano wire was used in deeper water), determining the position of the boat visually, recording the measured depth, and then taking another measurement a few meters farther along. This laborious process, while surprisingly accurate, still left large areas of the sea-bottom unmapped and unknown.

The First Charts

The process of compiling the Survey's first nautical charts was even more painstaking — a fact that proved to be another political problem for Hassler and his exacting methods. By 1843, he had still not produced a nautical chart for general distribution but had nearly overseen the completion of the New York Harbor series of six charts. Unfortunately, he did not live to see their publication in 1844-1845. These charts stand as monuments to his vision and methods.

Even as hydrographic surveying gathered steam under Alexander Dallas Bache, who became superintendent after Hassler's death in 1843, the Survey was confronted with a backlog of data ready for compilation into nautical charts for publication. The printing



Left: Tossing the leadline off the *Westdahl*. The leadline is vertical for reading. Below: The chart of the Sandy Hook Bar, New York Harbor entrance. Surveyed under the direction of Lt. Thomas R. Gedney, 1835. Hydrographic Survey H-53 helped publicize survey efforts by finding a new channel that made it easier and cheaper to enter and leave New York Harbor. Credits: NOAA Central Library Photo Collection

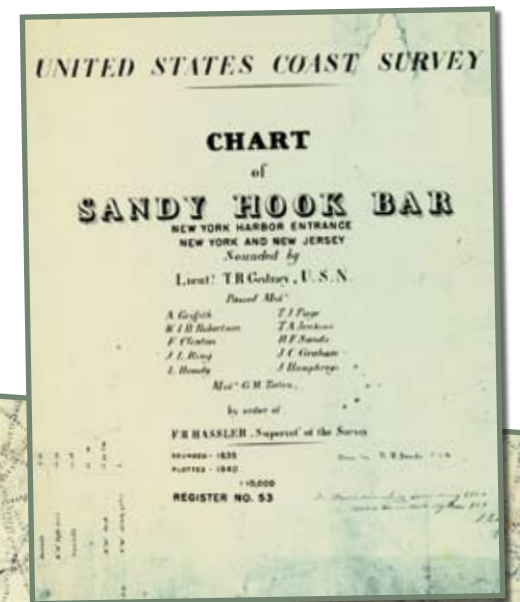
1990s, revisions of charts involved thousands of hours of labor: It usually took about 10 months from the time a revision was undertaken to the moment a new chart was printed.

Today's Surveys

It was under Bache's leadership that hydrographic surveyors also came to an important realization: the configuration of the seafloor was not static, but in constant flux, due to a number of natural and human-related changes. The first and most important goal of Coast Survey hydrography — to discover and chart hazards to navigation — was supplemented

of a chart required a hand-engraved copper plate that was often very large — as large as 10 square feet. Even for the most skilled engravers, which were in short supply in the mid-19th century United States, original plates took three to four years to create, and cost from \$3,000 to \$6,000 each.

Through electrotyping and photo-reducing practices developed and refined by the Survey during Bache's tenure, plates were copied much more quickly and cheaply, and charts were easily reduced to a number of scales — but the backlog remained, even as the Survey's first charts continued to roll off the presses. As recently as the



by others aimed at defining and describing more completely these underwater configurations and the multitude of factors that influenced their dynamics. The old method of lead-line soundings clearly would not fit the bill. Fortunately, just a few decades after the first primitive echosounding devices were used with some success by Coast and Geodetic Survey vessels during the 1920s and 1930s, sonar technologies were developed that would at last provide a complete picture of the sea floor.

Today's hydrographic surveys are conducted with two different types of sonar device. Multibeam sounding arrays, mounted directly on the hull of survey ships, emit a fan-shaped signal that

measures a number of precise depths in a swath perpendicular to the course of the vessel. Behind these survey vessels, a specialized "side-scanning" device, towed by cable, sends out a wide sonar swath that carefully maps the shape of the sea floor, including any objects or outcrops that might pose a hazard. Today survey ships use satellite-based Global Positioning System (GPS) to reference their own location to a fixed point on land. This establishes their location to within 3 to 5 meters.

Smart Charts

In little more than a decade, technology has also radically changed the way charts are both produced by NOAA's Office of the Coast Survey and used

CHARTING THE SKIES

In 1917, Secretary of the Navy Joseph Daniels commented prophetically to Ernest Lester Jones, director of the Coast and Geodetic Survey: "... We are on the threshold of a period when the battles of the world will not be fought on the land or sea alone, but in the air, and I look to you ... gentlemen to chart the air as you have charted the ocean."

Nine years later, in 1926 — 23 years after *Kitty Hawk* — the U.S. Department of Commerce created an Aeronautical Branch, the direct predecessor of today's Federal Aviation Administration (FAA), to promote interstate air commerce. The department assigned production of the required aeronautical charts to a well-established chart-making organization: the Coast and Geodetic Survey (C&GS).

C&GS published the first of its initial series of Strip Airway Maps, covering the route from Kansas City to Moline, Ill., just a month after Charles Lindbergh completed the world's first transatlantic flight in 1927. Within a few years, the agency was producing Sectional and Regional Charts that covered wider areas.

At the outbreak of World War II, the U.S. Army Air Forces contracted C&GS to produce a Western Hemisphere series of 120 aeronautical charts at the scale of 1:1,000,000. By 1943, the demand for the Survey's aeronautical charts had

ballooned from a prewar 464,000 units to 11,775,000 units, which were printed and distributed mostly for the Army and Navy. Additionally, new specialized aeronautical charts were required for the war effort. Some of these included a series of 1,812 target charts and charts for such areas as the Ploesti oil fields, Hiroshima, and Nagasaki.

In the postwar decades, the demand for aeronautical chart products increased significantly. And with the advent of many computerized technologies over the last two decades, many digital aeronautical charts and related information products have been added to support modern aircraft navigation systems. However, the paper aeronautical chart remains the most widely used air navigation reference.

In 2000, Congress directed the transfer of the Survey's Office of Aeronautical Charting and Cartography (AC&C — now the National Aeronautical Charting Group) to the FAA, where it supports the National Airspace System as the nation's civil aeronautical charting organization. Today, NOAA's National Geodetic Survey, a descendant of the C&GS, supports FAA's aeronautical charting program and other FAA aeronautical information programs by conducting aeronautical surveys at public use and general aviation airports throughout the United States.

by mariners. While it still does offer printed paper charts and makes digital images of these charts available on-line, perhaps the most promising chart format released today is the on-board electronic navigational chart (NOAA ENC®), a “smart” chart whose applications have only begun to be explored. The NOAA ENC® is a data set displayed in a real-time information system that may show a ship's position, speed, course, and draft, along with nearby soundings, way points, and warning systems. Such a system may use color-coded lines to differentiate between a ship's planned route and the actual course taken, and may display a vessel's projected course. Electronic charts can integrate NOAA ENC® with GPS satellite data and other sensor information (such as radar, tide

levels, winds, and weather) to enhance awareness of the immediate environment. An electronic chart, using a NOAA ENC® and GPS, automatically updates a vessel's location every one to two seconds, and indicates floating aids to navigation, other vessels in the area, and points of land. Electronic chart systems, with their ability to display NOAA ENC® on a shipboard computer, may be able to instantaneously detect hazards, estimate how long it would take to run into them, and automatically sound an alarm. The electronic chart with GPS has been hailed as the most significant advance in navigation since the advent of radar. Within a mere decade, it has been brought on board by an increasing number of vessels operating within U.S. waters. The days when navigators stooped

over tables with parallel plotters in their hands, below-decks, or in chart houses, are rapidly becoming a thing of the past.

The Race to Modernize

Now that the technology provides accurate, up-to-date nautical charts, the Office of the Coast Survey's work is far from finished — in fact, in many ways, it has only recently begun. Despite the fact that NOAA is the only organization authorized to create navigational charts of U.S. waters, its fleet of hydrographic survey vessels is astonishingly small. NOAA's Office of the Coast Survey is charged with exploring and charting 95,000 miles of coastline, as well as 3.4 million square nautical miles within the U.S. exclusive economic zone (EEZ), an area extending 200 miles beyond the nation's shores.

THE U.S. COAST AND GEODETIC SURVEY STEAMER *BLAKE*

The U.S. Coast Survey, in studying and surveying the nation's shores, was also a pioneer in the field of oceanography — a broad term used to denote the study of the earth's oceans and seas. Of all the ships in the Survey's fleet, the steamer *Blake*, commissioned in 1874, was unique in the number and significance of its contributions. In the winters of 1874-1877, with the use of a piano-wire sounding machine developed by her skipper, Charles Sigsbee, the *Blake*'s crew meticulously compiled a bathymetric map of the Gulf of Mexico — the first modern and accurate map of any portion of the ocean floor. This work also led to the development of the first three-dimensional model of a portion of the ocean floor.

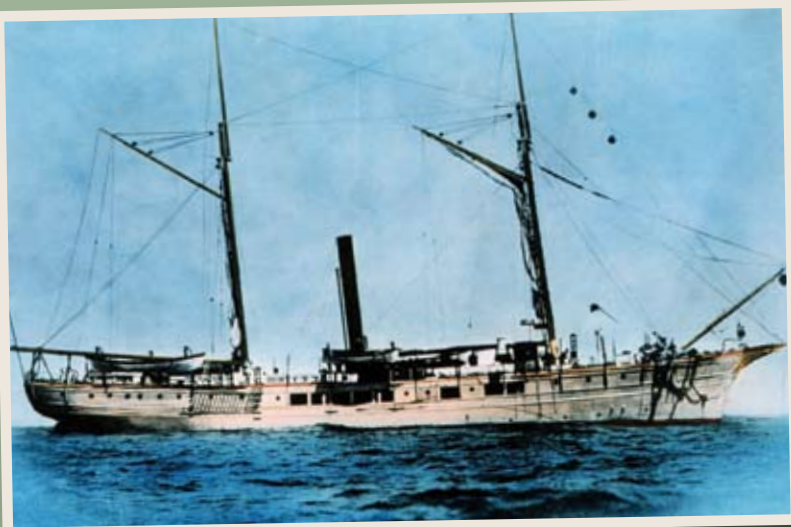
In the winter of 1877-1888, Sigsbee and the American scientist Alexander Agassiz pioneered the use of steel rope

for deep-sea dredging operations aboard the *Blake*. With this stronger, more compact, and more durable material, the *Blake* conducted 200 deep-sea dredgings in a single season. In comparison,

In 1885 the *Blake*, commanded by John Elliott Pillsbury, pioneered the use of steel rope to accomplish deep-sea anchoring for classic Gulf Stream studies and anchored in depths as great as 2200 fathoms (13,200 feet). This was the forerunner of all deep-sea anchoring systems including those used by meteorological and oceanographic buoys to study the deep-ocean harbingers of global phenomena such as El Niño.

In recognition of its exceptional lifetime of service and innovation, the *Blake* — which was burnt and lost off Frying Pan Shoal, North Carolina, in 1908 — is one of the few oceanographic ships

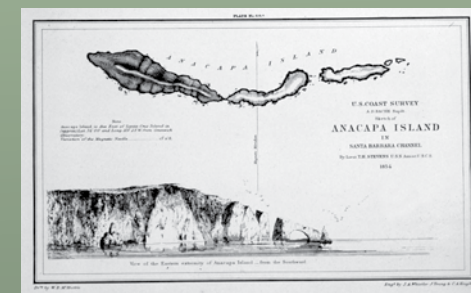
to have its name inscribed on the façade of Monaco's world-famous cliff-top Oceanographic Museum.



The *Blake* anchored off Windward Passage. George Belknap shipped Thomson's piano wire machine to the *Blake* in 1875. Charles Sigsbee modified Thomson's machine. Sigsbee's sounding machine was the standard for many years. Credit: NOAA Central Library Photo Collection

WHISTLER: A COAST & GEODETIC SURVEY EMPLOYEE

CONTRIBUTED BY DORIA B. GRIMES



Whistler's Anacapa Island engraving from a William B. McMurtrie sketch. Credit: NOAA Central Library Photo Collection

For example, he arbitrarily inserted two flocks of gulls on copper plate 414A – Anacapa Island. This and his tardiness, in large part, contributed to his resignation, to the mutual satisfaction of the employer and employee.

In the same year he left for Paris and London, where he subsequently achieved fame as one of America's greatest artists and expatriates.

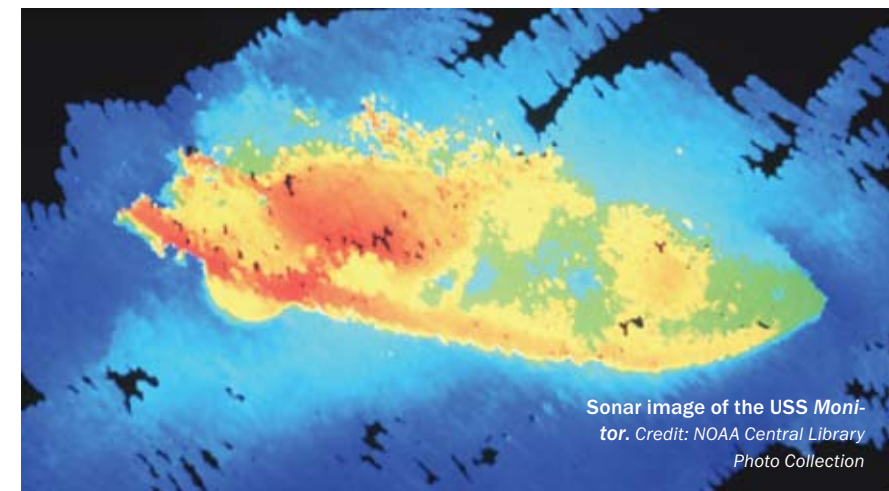
<http://www.history.noaa.gov/art/whistler.html>

There is still — as there was in the days of Alexander Dallas Bache — a significant backlog of requests for hydrographic surveys and updated charts. As recently as 1995, the Office of the Coast Survey estimated that 60 percent of NOAA's nautical charts were based on data collected with a lead-line or primitive echo sounders.

The trend in commercial shipping (which carries 95 percent of U.S. international trade and is projected to double or even triple in volume by the year 2020) has been toward fewer but larger vessels, some with drafts greater than 60 feet — the height of a six-story building

submerged beneath the water's surface. In U.S. ports and harbors, clearances are in some cases down to a matter of two feet or less between cargo ship hulls and dredged channel bottoms. Given estimates that range between \$38,000 and \$288,000 in profit added for each additional foot of draft carried by large bulk and container ships, it's likely that commercial shippers will continue to push against subsurface limits — and rely increasingly on NOAA charts that are accurate and up-to-date NOAA charts.

NOAA Charting and Navigation — www.noaa.gov/charts.html



Sonar image of the USS *Monitor*. Credit: NOAA Central Library Photo Collection